CLAIMS

What is claimed is:

1. A network having a plurality of multicast connections, said network comprising:

an input stage comprising r_1 input switches, and n_1 inlet links for each of said r_1 input switches;

an output stage comprising r_2 output switches, and n_2 outlet links for each of said r_2 output switches; and

a middle stage comprising m middle switches, and each middle switch comprising at least one link (hereinafter "first internal link") connected to each input switch for a total of at least r_1 first internal links, each middle switch further comprising at least one link (hereinafter "second internal link") connected to each output switch for a total of at least r_2 second internal links;

said network further is always capable of setting up said multicast connection by never changing path of an existing multicast connection, and the network is hereinafter "strictly nonblocking network", where m is a minimum of at least $2*n_1+n_2-1$.

2. The network of claim 1 wherein each multicast connection from an inlet link passes through at most two middle switches, and said multicast connection further passes to a plurality of outlet links from said at most two middle switches.

3. The network of claim 1 further comprising a controller coupled to each of said input, output and middle stages to set up said multicast connection.

4. The network of claim 1 wherein said r_1 input switches and r_2 output switches are the same number of switches.

5. The network of claim 1 wherein said n_1 inlet links and n_2 outlet links are the same number of links and $n_1=n_2=n$, then m is a minimum of at least $3*n-1$.

6. The network of claim 1,

wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

7. A method for setting up one or more multicast connections in a network having an input stage having $n_1 * r_1$ inlet links and r_1 input switches, an output stage having $n_2 * r_2$ outlet links and r_2 output switches, and a middle stage having m middle switches, where each middle switch is connected to each of said r_1 input switches through r_1 first internal links and each middle switch further comprising at least one link connected to at most d said output switches for a total of at least d second internal links, wherein $1 \leq d \leq r_2$, said method comprising:

receiving a multicast connection at said input stage;

fanning out said multicast connection in said input stage into at most two middle switches to set up said multicast connection to a plurality of output switches among said r_2 output switches, wherein said plurality of output switches are specified as destinations of said multicast connection, wherein first internal links from said input switch to said at most two middle switches and second internal links to said destinations from said at most two middles switches are available;

wherein said act of fanning out is performed without changing any existing connection to pass through another middle switch.

8. The method of claim 7 wherein said act of fanning out is performed recursively.

9. A method for setting up one or more multicast connections in a network having an input stage having $n_1 * r_1$ inlet links and r_1 input switches, an output stage having $n_2 * r_2$ outlet links and r_2 output switches, and a middle stage having m middle switches, where each middle switch is connected to each of said r_1 input switches through r_1 first internal links and each middle switch further comprising at least one link connected to at most d said output switches for a total of at least d second internal links, wherein $1 \leq d \leq r_2$, said method comprising:

checking if at least a first subset of destination output switches of said multicast connection have available second internal links to a first middle switch; and

checking if a second middle switch has available second internal links to a second subset of destination output switches of said multicast connection.

wherein each destination output switch of said multicast connection is one of said first subset of destination output switches and said second subset of destination output switches.

10. The method of claim 9 further comprising:

checking if the input switch of said multicast connection has an available first internal link to said first middle switch and to said second middle switch.

11. The method of claim 9 further comprising:

prior to said checkings, checking if all the destination output switches of said multicast connection are available at said first middle switch.

12. The method of claim 9 further comprising:

repeating said checkings of available second internal links to another second subset of destination output switches for each middle switch other than said first and said second middle switches.

wherein each destination output switch of said multicast connection is one of said first subset of destination output switches and said second subset of destination output switches.

13. The method of claim 9 further comprising:

repeating said checkings of available second internal links to another first subset of destination output switches with each middle stage switch other than said first middle stage switch.

14. The method of claim 9 further comprising:

repeating said checkings of available first internal link to each middle stage switch other than said first middle switch and said second middle switch.

15. The method of claim 9 further comprising:

setting up each of said multicast connection from its said input switch to its said output switches through not more than two middle switches, selected by said checkings, by fanning out said multicast connection in its said input switch into not more than said two middle stage switches.

16. The method of claim 9 wherein any of said acts of checking and setting up are performed recursively.

17. A method of setting up a multicast connection through a three-stage network, said method comprising:

fanning out only one or two times in an initial stage,

and fanning out any number of times in each of the remaining stages,

wherein said three-stage network includes said remaining stages and said initial stage.

18. The method of claim 17 further comprising:

repeating said acts of fanning out with a plurality of portions of each of said stages.

19. The method of claim 17 further comprising:

recursively performing said act of fanning out.

20. The method of claim 17 wherein:

a remaining stage immediately following said initial stage comprises internal links that are at least two times the total number of inlet links of said initial stage.

21. The method of claim 17 wherein:

said initial stage comprises a plurality of first switches, and a plurality of inlet links connected to each said first switch; and

a remaining stage immediately following said initial stage comprises a plurality of second switches, that are at least double the number of inlet links of each first switch and

each second switch comprises a plurality of internal links at least equal in number to the number of first switches in said initial stage.

22. A network having a plurality of multicast connections, said network comprising:

an input stage comprising r_1 input switches and n_1 inlet links for each of said r_1 input switches, and $N_1 = n_1 * r_1$;

an output stage comprising r_2 output switches and n_2 outlet links for each of said r_2 output switches, and $N_2 = n_2 * r_2$; and

a middle stage comprising m middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least r_1 first internal links; each middle switch further comprising at least one link connected to each output switch for a total of at least r_2 second internal links,

said network further is always capable of setting up said multicast connection by never changing path of an existing multicast connection, and the network is hereinafter "strictly nonblocking network", where m is a minimum of at least $3 * n_1 + n_2 - 1$.

23. The network of claim 22 wherein each multicast connection from an inlet link passes through at most three middles switches, and said multicast connection further passes to a plurality of outlet links from said at most three middle switches.

24. The network of claim 22 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

25. The network of claim 22 wherein said r_1 input switches and r_2 output switches are the same number of switches.

26. The network of claim 22 wherein said n_1 inlet links and n_2 outlet links are the same number of links and $n_1 = n_2 = n$, then m is a minimum of at least $4 * n - 1$.

27. The network of claim 22,

wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

28. A method for setting up one or more multicast connections in a network having an input stage having $n_1 * r_1$ inlet links and r_1 input switches, an output stage having $n_2 * r_2$ outlet links and r_2 output switches, and a middle stage having m middle switches, where each middle switch is connected to each of said r_1 input switches through r_1 first internal links and each middle switch further comprising at least one link connected to at most d said output switches for a total of at least d second internal links, wherein $1 \leq d \leq r_2$, said method comprising :

receiving a multicast connection at said input stage;

fanning out said multicast connection in said input stage into at most three middle switches to set up said multicast connection to a plurality of output switches among said r_2 output switches of said multicast connection, wherein said plurality of output switches are specified as destinations of said multicast connection, wherein first internal links from said input switch to said at most three middle switches and second internal links to said destinations from said at most three middle switches are available,

wherein said act of fanning out is performed without changing any existing connection to pass through another middle switch.

29. The method of claim 28 wherein said act of fanning out is performed recursively.

30. A method for setting up one or more multicast connections in a network having an input stage having $n_1 * r_1$ inlet links and r_1 input switches, an output stage having $n_2 * r_2$ outlet links and r_2 output switches, and a middle stage having m middle switches, where each middle switch is connected to each of said r_1 input switches through r_1 first internal links and each middle switch further comprising at least one link connected to at most d said output switches for a total of at least d second internal links, wherein $1 \leq d \leq r_2$, said method comprising :

checking if all the destination output switches of said multicast connection have available second internal links from at most three middle switches.

31. The method of claim 30 further comprising:

checking if the input switch of said multicast connection has available first internal links to at most said three middle switches.

32. The method of claim 30 further comprising:

repeating said checkings of available second internal links to all said destination output switches for all the other combinations of at most three middle switches.

33. The method of claim 30 further comprising:

repeating said checkings of available first internal links for all the other combinations of at most three middle switches.

34. The method of claim 30 further comprising:

setting up each of said connection from its said input switch to its said output switches through at most said three middle switches, selected by said checkings, by fanning out said multicast connection in its said input switch into at most said three middle stage switches;

35. The method of claim 30 wherein any of said acts of checking and setting up are performed recursively.

36. A method of setting up a multicast connection through a three-stage network, said method comprising:

fanning out at most three times in an initial stage,

and fanning out any number of times in each of the remaining stages,

wherein said three-stage network includes said remaining stages and said initial stage.

37. The method of claim 36 further comprising:

repeating said acts of fanning out with a plurality of portions of each said stages.

38. The method of claim 36 further comprising:

recursively performing said act of fanning out.

39. The method of claim 36 wherein:

a remaining stage immediately following said initial stage comprises internal links that are at least three times the total number of inlet links of said initial stage.

40. The method of claim 36 wherein:

said initial stage comprises a plurality of first switches, and plurality of inlet links connected to each said first switch; and

a remaining stage immediately following said initial stage comprises a plurality of second switches, that are at least three times the number of inlet links of each first switch and each second switch comprises a plurality of first internal links at least equal in number to the number of first switches in said initial stage.

said multicast connections having a fan-out of one or more in said middle stage.

41. A network having a plurality of multicast connections, said network comprising:

an input stage comprising r_1 input switches and n_1 inlet links for each of said r_1 input switches, and $N_1 = n_1 * r_1$;

an output stage comprising r_2 output switches and n_2 outlet links for each of said r_2 output switches, and $N_2 = n_2 * r_2$; and

a middle stage comprising m middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least r_1 first internal links; each middle switch further comprising at least one link connected to each output switch for a total of at least r_2 second internal links, for $x \geq 1$,

said network further is always capable of setting up said connection by never changing path of a previously set up multicast connection, and the network is hereinafter "strictly nonblocking network", where $m \geq x * n_1 + n_2 - 1$, for $x \geq 2$.

42. The network of claim 41 wherein each multicast connection from an inlet link passes through at most x middles switches, and said multicast connection further passes to a plurality of outlet links from said at most x middle switches.

43. The network of claim 41 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

44. The network of claim 41 wherein said r_1 input switches and r_2 output switches are the same number of switches.

45. The network of claim 41 wherein said n_1 inlet links and n_2 outlet links are the same number of links and $n_1 = n_2 = n$, then $m \geq (x+1) * n - 1$.

46. The network of claim 41,

wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

47. A method for setting up one or more multicast connections in a network having an input stage having $n_1 * r_1$ inlet links and r_1 input switches, an output stage having $n_2 * r_2$ outlet links and r_2 output switches, and a middle stage having m middle switches, where each middle switch is connected to each of said r_1 input switches through r_1 first internal links and each middle switch further comprising at least one link connected to at most d said output switches for a total of at least d second internal links, wherein $1 \leq d \leq r_2$, for $x \geq 2$, said method comprising:

receiving a multicast connection at said input stage;

fanning out said multicast connection in said input stage into at most x middle switches to set up said multicast connection to a plurality of output switches among said r_2 output switches, wherein said plurality of output switches are specified as destinations of said multicast connection, wherein first internal links from said input switch to said at most x middle switches and second internal links to said destinations from said at most x middles switches are available,

wherein said act of fanning out is performed without changing any existing connection to pass through another middle switch.

48. The method of claim 47 wherein said act of fanning out is performed recursively.

49. A method for setting up one or more multicast connections in a network having an input stage having $n_1 * r_1$ inlet links and r_1 input switches, an output stage having $n_2 * r_2$ outlet links and r_2 output switches, and a middle stage having m middle switches, where each middle switch is connected to each of said r_1 input switches through r_1 first internal links and each of said r_2 said output switches through r_2 second internal links, for $x \geq 2$, said method comprising:

checking if all the destination output switches of said multicast connection have available second internal links from at most x middle switches.

50. The method of claim 49 further comprising:

checking if the input switch of said multicast connection has an available first internal links to said at most x middle switches.

51. The method of claim 49 further comprising:

repeating said checkings of available second internal links to all said destination output switches for all the other combinations of at most x middle switches.

52. The method of claim 49 further comprising:

repeating said checkings of available first internal links for all the other combinations of at most x middle switches.

53. The method of claim 49 further comprising:

setting up each of said connection from its said input switch to its said output switches through at most x said middle switches, selected by said checkings, by fanning out said multicast connection in its said input switch into at most said x middle stage switches.

54. The method of claim 49 wherein any of said acts of checking and setting up are performed recursively.

55. A method of setting up a multicast connection through a three-stage network, for $x \geq 2$, said method comprising:

fanning out at most x times in an initial stage,

and fanning out any number of times in each of the remaining stages,

wherein said three-stage network includes said remaining stages and said initial stage.

56. The method of claim 55 further comprising:

repeating said acts of fanning out with a plurality of portions of each of said stages.

57. The method of claim 55 further comprising:

recursively performing said act of fanning out.

58. The method of claim 55 wherein:

a remaining stage immediately following said initial stage comprises internal links that are at least x times the total number of inlet links of said initial stage.

59. The method of claim 55 wherein:

said initial stage comprises a plurality of first switches, and plurality of inlet links connected to each said first switch; and

a remaining stage immediately following said initial stage comprises a plurality of second switches that are at least x times the number of inlet links of each first switch and each second switch comprises a plurality of first internal links at least equal in number to the number of first switches in said initial stage.

60. A network having a plurality of multicast connections, said network comprising:

an input stage comprising r_1 input switches and n_1 inlet links for each of said r_1 input switches, and $N_1 = n_1 * r_1$;

an output stage comprising r_2 output switches and n_2 outlet links for each of said r_2 output switches, and $N_2 = n_2 * r_2$; and

a middle stage comprising m middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least r_1 first internal links; each middle switch further comprising at least one link connected to at

most d said output switches for a total of at least d second internal links, wherein $1 \le d \le r_2$,

wherein $m \ge \sum_{i=1}^{P}(x_i * a_i + n_1 - 1)$, where $\sum_{i=1}^{P} a_i = n_1 + n_2$ and $x_1, x_2, ..., x_p \ge 1$;

wherein, for $1 \le i \le p$, multicast connections from a_i inlet links of each input switch pass through at most x_i middles switches,

said network further is capable of setting up said connection by never changing path of a previously set up multicast connection, and the network is hereinafter "strictly nonblocking network", where $x_1, x_2, ..., x_p \ge 2$.

61. The network of claim 60 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

62. The network of claim 60 wherein said r_1 input switches and r_2 output switches are the same number of switches.

63. The network of claim 60 wherein said n_1 inlet links and n_2 outlet links are the same number of links and $n_1 = n_2 = n$.

64. The network of claim 60,

wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

65. A network having a plurality of multicast connections, said network comprising:

an input stage comprising r_1 input switches and n_1 inlet links for each of said r_1 input switches, and $N_1 = n_1 * r_1$;

an output stage comprising r_2 output switches and n_2 outlet links for each of said r_2 output switches, and $N_2 = n_2 * r_2$; and

a middle stage comprising m middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least r_1 first internal links; each middle switch further comprising at least one link connected to at

most d said output switches for a total of at least d second internal links, wherein $1 \le d \le r_2$,

said network further is always capable of setting up said connection by never changing path of a previously set up multicast connection, and the network is hereinafter "strictly nonblocking network", where m is a minimum of at least $2 * n_1 + n_2 - 1$.

66. The network of claim 65 wherein each multicast connection from an inlet link passes through at most one or two middles switches, and said multicast connection further passes a plurality of outlet links from said at most two middle switches.

67. The network of claim 65 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

68. The network of claim 65 wherein said r_1 input switches and r_2 output switches are the same number of switches.

69. The network of claim 65 wherein said n_1 inlet links and n_2 outlet links are the same number of links and $n_1 = n_2 = n$, then m is a minimum of at least $3 * n - 1$.

70. The network of claim 65,

wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

71. A network having a plurality of multicast connections, said network comprising:

an input stage comprising r_1 input switches and n_1 inlet links for each of said r_1 input switches, and $N_1 = n_1 * r_1$;

an output stage comprising r_2 output switches and n_2 outlet links for each of said r_2 output switches, and $N_2 = n_2 * r_2$; and

a middle stage comprising m middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least r_1 first internal links; each middle switch further comprising at least one link connected to at

most d said output switches for a total of at least d second internal links, wherein $1 \leq d \leq r_2$,

said network further is always capable of setting up said connection by never changing path of a previously set up multicast connection, and the network is hereinafter "strictly nonblocking network", where m is a minimum of at least $3 * n_1 + n_2 - 1$.

72. The network of claim 71 wherein each multicast connection from an inlet link passes through at most three middles switches, and said multicast connection further passes a plurality of outlet links from said at most three middle switches.

73. The network of claim 71 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

74. The network of claim 71 wherein said r_1 input switches and r_2 output switches are the same number of switches.

75. The network of claim 71 wherein said n_1 inlet links and n_2 outlet links are the same number of links and $n_1 = n_2 = n$, then m is a minimum of at least $4 * n - 1$.

76. The network of claim 71 ,

wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

77. A network having a plurality of multicast connections, said network comprising:

an input stage comprising r_1 input switches and n_1 inlet links for each of said r_1 input switches, and $N_1 = n_1 * r_1$;

an output stage comprising r_2 output switches and n_2 outlet links for each of said r_2 output switches, and $N_2 = n_2 * r_2$; and

a middle stage comprising m middle switches, and each middle switch comprising at least one link connected to each input switch for a total of at least r_1 first internal links; each middle switch further comprising at least one link connected to at

most d output switches for a total of at least d second internal links, wherein $1 \leq d \leq r_2$, for $2 \leq x \leq r_2$,

said network further is always capable of setting up said connection by never changing path of a previously set up multicast connection, and the network is hereinafter "strictly nonblocking network", where $m \geq x * n_1 + n_2 - 1$.

78. The network of claim 77 wherein each multicast connection from an inlet link passes through at most x middles switches, and said multicast connection further passes a plurality of outlet links from said at most x middle switches.

79. The network of claim 77 comprising a controller in communication with said input, output and middle stages to set up said multicast connection.

80. The network of claim 77 wherein said r_1 input switches and r_2 output switches are the same number of switches.

81. The network of claim 77 wherein said n_1 inlet links and n_2 outlet links are the same number of links and $n_1 = n_2 = n$, then $m \geq (x+1) * n$.

82. The network of claim 77,

wherein each of said input switches, or each of said output switches, or each of said middle switches further recursively comprise one or more networks.

83. A network comprising a plurality of input subnetworks, a plurality of middle subnetworks, and a plurality of output subnetworks, wherein at least one of said input subnetworks, said middle subnetworks and said output subnetworks recursively comprise:

an input stage comprising r_1 input switches and n_1 inlet links for each of said r_1 input switches;

an output stage comprising r_2 output switches and n_2 outlet links for each of said r_2 output switches; and

a middle stage, said middle stage comprising m middle switches, and each middle switch comprising at least one link (hereinafter "first internal link") connected to each input switch for a total of at least r_1 first internal links, each middle switch further comprising at least one link (hereinafter "second internal link") connected to at most d said output switches for a total of at least d second internal links, wherein $1 \leq d \leq r_2$, and for $x \leq 2$;

wherein each multicast connection from an inlet link passes through at most x middle switches, and said multicast connection further passes to a plurality of outlet links from said at most x middle switches.

Table 1 below shows the correspondence of the Claims between the current patent application and Amendment A.

Table 1 Correspondence of Claims between the patent application 09/967106 and Amendment A

09/967,106	AMENDMENT A		09/967,106	AMENDMENT A
1	1			33 added
2-3	Merged with 1		42-43	34-35
	2 (separated from 1)		44	36
4-6	3-5		45	Merged with 36
7	Deleted		46-49	37-40
8	6		50-52	deleted
9	7		53	41
10	Merged into 7		54-55	Merged with 41
11	8			42 (separated from 41)
12-16	9-13		56-58	43-45
	14 added		59	Deleted
17-18	15-16		60	46
19	17		61	47
20	Merged with 17		62	Merged into 47
21-24	18-21		63	48
25-27	Deleted		64-66	49-51
28	22			52 added
29-30	Merged with 22		67-68	53-54
	23 (separated from 22)		69	55
31-33	24-26		70	Merged with 55
34	Deleted		71-74	56-59
35	27		75-77	deleted
36	28		78	60
37	Merged into 28		79	Merged with 60
38	29		80-82	61-63
39-41	30-32		83	Deleted

09/967,106	AMENDMENT A		09/967,106	AMENDMENT A
84	64		96-98	73-75
85	65		99	Deleted
86-87	Merged with 65		100	76
	66 (separated from 65)		101	77
88	67		102-103	Merged with 77
89-90	68-69			78 (separated from 77)
91	Deleted		104-106	79-81
92	70		107	Deleted
93	71		108	82
94-95	Merged with 71		109	83
	72 (separated from 71)			

A GUIDE TO GO THROUGH THE CLAIMS IN AMENDMENT A:

Applicant also provides the following breakdown of the claims to go through the claims easily:

1) Claims with fan-out of at most two in the first stage:

Claims 1-6: 3-stage network.

Claims 7-8: Key method.

Claims 9-16: Detailed steps method.

Claims 17-21: Key method in a generic network.

2) Claims with fan-out of at most three in the first stage:

Claims 22-27: 3-stage network.

Claims 28-29: Key method.

Claims 30-35: Detailed steps method.

Claims 36-40: Key method in a generic network.

3) Claims with fan-out of at most any x (>= 2) in the first stage:

Claims 41-46: 3-stage network.

Claims 47-48: Key method.

Claims 49-54: Detailed steps method.

Claims 55-59: Key method in a generic network.

4) Claims with fan-out of arbitrary mix of at most any x (>= 2) in the first stage:

Claims 60-64: 3-stage network.

5) Claims with fan-out of at most two in the first stage:

Claims 65-70: 3-stage network for a subset of output switches.

6) Claims with fan-out of at most three in the first stage:

Claims 71-76: 3-stage network for a subset of output switches.

7) Claims with fan-out of at most any x (>= 2) in the first stage:

Claims 77-82: 3-stage network for a subset of output switches.